EE 492 Bi-Weekly Report 5 - sddec18-03

Design of a More Reliable Power Grid for Puerto Rico

11/6/2018 - 11/19/2018

Faculty Advisor: Vikram Dalal

Team Members

Logan Lillis - *Communications and Reports Lead*
Ricardo Rodriguez-Menas - *Webmaster and Project Plan Lead*
Heiqal Zamri - *Test Engineer Lead*
Pinjia Zhang - *Design Lead*

Weekly Summary

This biweekly period, we began to finalize our proposals for the main areas of proposal: generation, transmission, renewable energy, urban microgrid implementation, and rural microgrid implementation. Between presentations to Professor Dalal, we also presented to the other senior design groups in our second PIRM review. During week 2, Logan formatted and began authoring our final written proposal, which the group will continue to write.

Past Week Accomplishments

Logan:

- Presentation on Natural Gas Pipelines
  - Approx. 50 mile proposed pipeline from Roosevelt Roads to two major San Juan generating facilities.
  - Labor costs are #1 influencer(47%)
    - Between $2.0 - 3.6 million/mile
  - Total Costs (including Right of Way costs, labor, materials, and miscellaneous costs)
    - $7.65 million/mile (twice as much as 2015

- Material-$992,991/mile, down from $1,012,698/mile 2014-15.
- Labor-$3,603,334/mile, up from $1,977,938/mile for 2014-15.
- Miscellaneous-$2,615,028/mile, up from $1,867,393/mile for 2014-15.
- ROW and damages-$441,548/mile, up from $378,255/mile for 2014-15.

Source:https://www.ogj.com/articles/print/volume-114/issue-9/special-report-pipeline-economics/natural-gas-pipeline-profits-construction-both-up.html

- ➢ Researched US pricing breakdown for pipelines.
  - ■ *How to factor labor costs in for Puerto Rico? No professional workforce like on mainland.*

US PIPELINE COSTS, ESTIMATED

Table 4

Size, in.	Location[1]	Length, miles	$ Material	Labor	Misc.[2]	ROW & damages	Total	$/mile
LAND PIPELINES								
4	Pennsylvania	4.88	150,605	1,149,540	613,838	257,047	2,171,030	444,883
	South Carolina	5.00	284,525	1,693,643	1,683,832	544,799	4,206,799	841,360
6-30	Pennsylvania-West Virginia	7.87	8,133,000	34,760,000	17,701,771	1,200,000	61,794,771	7,851,940
12	Louisiana-Mississippi	51.78	11,203,427	32,056,680	21,351,501	1,592,820	66,204,428	1,278,571
	South Carolina	55.00	8,971,797	46,646,137	25,484,993	5,751,434	86,854,361	1,579,170
12-30	Mass.-NH-Conn. (lat.)(L)	58.00	38,060,000	220,446,000	191,025,000	117,916,000	567,447,000	9,783,569
12-36	WV-Virgnia	29.20	17,219,213	135,180,459	91,983,781	16,175,337	260,558,790	8,923,246
16	New York (lat.)	7.80	3,244,637	15,110,700	11,494,570	2,084,848	31,934,755	4,094,199
20	New York	1.20	607,114	3,604,780	1,761,759	101,000	6,074,653	5,062,211
	Pennsylvania /R/	21.00	9,792,291	52,477,600	22,961,374	8,370,878	93,602,143	4,457,245
	North Carolina-Virginia	77.60	22,502,610	216,184,650	148,987,763	11,421,595	399,096,618	5,142,998
24	New York /R/	7.00	2,363,550	14,152,672	5,853,727	938,000	23,307,949	3,329,707
30	Louisiana (lat.)	3.00	2,897,992	9,874,969	6,991,431	573,560	20,337,952	6,779,317
	West Virginia /R/	3.85	4,555,018	25,243,061	8,214,385	2,752,179	40,764,643	10,588,219
	Pennsylvania-West Virginia	37.50	27,127,894	175,000,000	76,978,540	5,639,785	284,746,219	7,593,233
	Pennsylvania-New York	131.00	117,371,000	468,842,000	361,612,000	89,540,000	1,037,365,000	7,918,817
	NY-Mass.-NH	188.00	182,445,000	1,108,390,000	784,008,000	168,967,000	2,243,810,000	11,935,160
36	Ohio (L)	4.40	3,694,111	14,568,330	14,413,735	4,958,710	37,634,886	8,553,383
	Ohio	4.60	4,001,317	14,803,627	19,672,497	3,068,658	41,546,099	9,031,761
	Pennsylvania (L)	7.00	9,994,396	35,558,432	35,928,854	5,938,321	87,420,003	12,488,572
	Ohio	9.06	6,636,303	26,511,841	29,984,975	5,348,005	68,481,124	7,558,623
	Pennsylvania (L)	12.91	18,278,688	49,564,160	60,535,886	8,851,748	137,230,482	10,629,782
	Pennsylvania (L)(lat.)	41.00	49,277,000	187,655,000	115,201,000	24,640,000	376,773,000	9,189,585
	Texas	66.00	73,543,447	2,012,730	203,846,401	11,539,694	290,942,272	4,408,216
	Pennsylvania-New Jersey	114.00	127,241,054	552,912,900	164,814,512	93,623,611	938,592,077	8,233,264
	West Virginia	170.10	124,422,852	814,408,049	533,288,314	96,276,251	1,568,395,466	9,220,432
	North Carolina	181.50	163,079,520	648,108,235	419,060,826	24,867,143	1,255,115,724	6,915,238
	Ohio-Michigan	255.90	195,540,774	514,196,619	798,040,506	157,679,166	1,665,457,065	6,508,234
42	New York-Connecticut	6.30	8,684,775	76,936,367	85,039,846	17,429,504	188,090,492	29,855,634
	Louisiana (lat.)	42.70	80,000,000	160,000,000	104,545,279	—	344,545,279	8,068,976
	Texas	274.00	479,138,899	468,203,355	323,960,732	39,828,080	1,311,131,066	4,785,150
	WV-Va.-NC	292.80	344,491,422	1,498,099,754	1,011,071,411	54,409,763	2,908,072,350	9,931,941
	WV-Virginia	301.00	310,661,868	1,286,512,363	768,720,119	109,641,667	2,475,536,017	8,224,372
Total projects—land		**2472.95**	**$2,455,616,099**	**$8,910,864,653**	**$6,466,833,158**	**$1,091,926,603**	**$18,925,240,513**	**$7,652,901**
Total land-2015 report		**2192.16**	**$2,219,997,036**	**$4,335,957,101**	**$4,093,624,445**	**$829,195,731**	**$11,478,774,316**	**$5,236,285**
OFFSHORE PIPELINES								
Total projects—offshore		—	—	—	—	—	—	—
Total—all projects		**2472.95**	**$2,455,616,099**	**$8,910,864,653**	**$6,466,833,158**	**$1,091,926,603**	**$18,925,240,513**	**$7,652,901**
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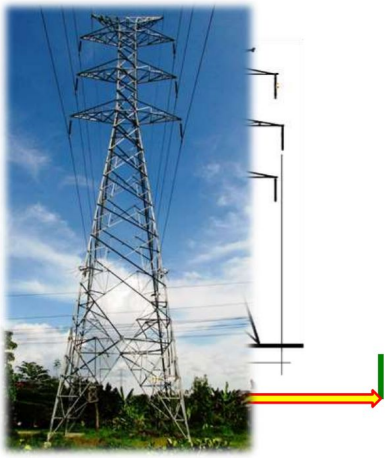
[1]L = loop; R = replacement; lat. = lateral. [2]Generally includes surveys, engineering, supervision, interest, administration, overheads, contingencies, allowances for funds used during construction (AFUDC), and FERC fees.
Source: US FERC construction-permit applications, July 1, 2015, to June 30, 2016.

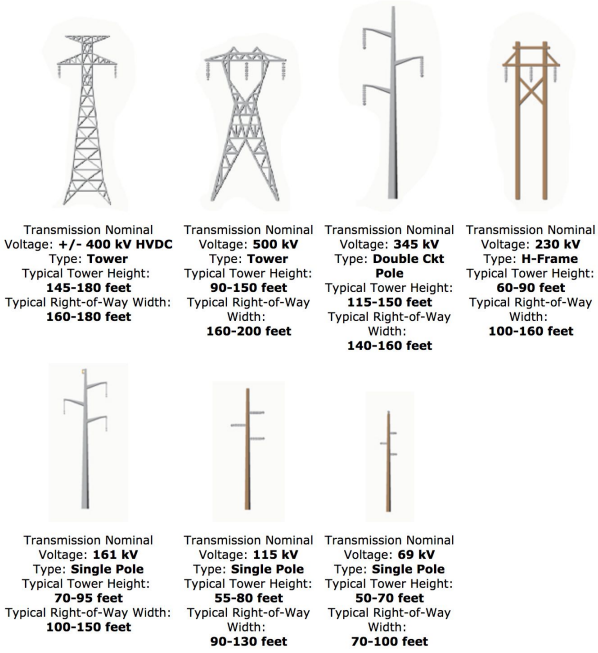
- ❖ Presentation on Right of Ways
  - ➢ Forest covers over 50% of island
    - ■ Was as low as 6% in 1940's (agricultural boom)
  - ➢ PREPA proposed a $50 million vegetation management plan
    - ■ The existing average maintenance is only $17.1 million
  - ➢ Backbone transmission is 230KV
    - ■ Proposing monopoles vs lattice towers

ROW Width Determination



Voltage Level (kV)	FIXED Width (m)
69	15
115	30
138	30
230	**40**
345	50
500	65

Thailand ROW width Determination



US ROW width determination (with pole type)

- Creation and Formatting of final written proposal
- Gathering group information for IRP poster

Ricardo:

- Research Tesla Powerwall and Powerpack pricing and rates
  - Priority of Professor Dalal
- Research on BYD pricing and rates
  - Recommended by Midamerican Energy.
  - Reached out for a quote, waiting on a response.

- Research on DC microgrids
  - Research on feasibility, cost, and efficiency of small scale DC microgrids.

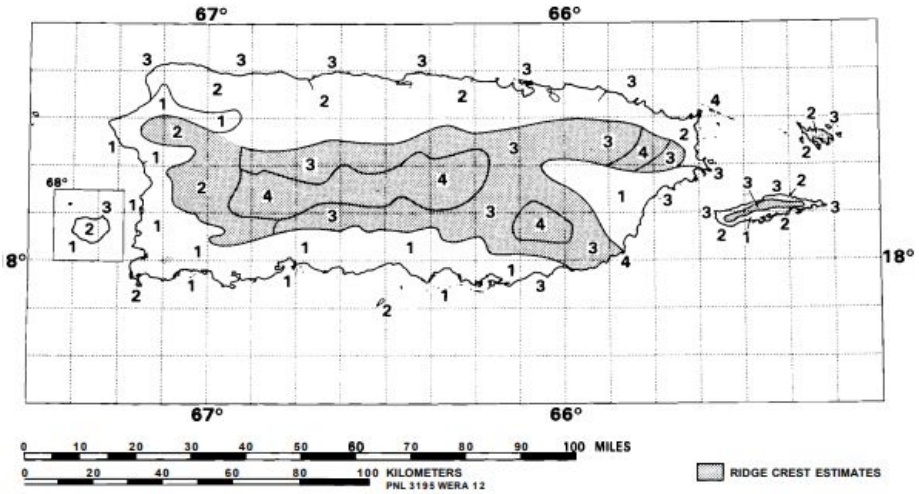
Heiqal:

- Research on Energy Storage
  - The cost and amount of energy storage needed for microgrids were achieved. Each energy storage should be able to supply up to 4-6 houses based on the usage of it. With this concept we understand that there will be many energy storage for each microgrid around the island.
- Research on microgrids compared to population density
  - The population of the country is 3.3 million, therefore we will require to supply power to the whole island and the microgrids based on the size density. We have concluded to make the microgrids big enough to sustain up to a population between the range of 3000 to 5000 residents. With this we can estimate the cost of the energy storages and solar panels needed for this design.
- Research on microgrid distribution
  - There is a problem with the variation of population density when we talk about the distribution of the microgrids. There are mountainous areas where there are small communities compared to cities like San Juan which has 355000 residents. Therefore to distribute the microgrids and to estimate the cost, we will focus mainly on the north east part of the island as the testing area. We will base the cost off the population of San Juan and estimate how much it would be to implement the components needed for the microgrids.
- Sources:
  - https://www.eia.gov/state/?sid=RQ
  - http://en.byd.com/usa/
  - https://en.wikipedia.org/wiki/San_Juan,_Puerto_Rico

Pinjia:

- Research on the Wind class distribution of Puerto Rico in different seasons. The most abundant wind resource is lying across the latitude range of 18.0 to 18.06N through out the island. There is currently a 1800kw wind grid at Punta located at east coast. The total nominal power is about 23400kw. So there is a possibility that we can set the wind farm among this location and integrate with the previous microgrid design to improve the resistivity to hurricane. According to previous hurricane data, it occasionally strikes south coast of the island and lead to severe damage.However, if we have those wind farm inside of island and connect it through the transmission line to microgrids we can still have normal operation wind farm as hurricane strikes. Asymmetrical electricity transmission may be preferred since it can combine pv wind perfectly.

Punta Lima Wind Farm



Ridge Crest Estimates

- Figure out the population density of San Juan for the solar grid design because it has largest population among the city in Puerto Rico. An estimation of solar farm in San Jose is necessary.
  - San Jose has 8,253 people per sq mi and has a total population of 395,000. As estimated by NREL lab, a total of 700MW solar grid is desired for the necessary power sustain. Large scale solar farm is independent from the asymmetrical microgrids-pv-wind system and should be used near population centers for better efficiency.
- DER wind turbine for each of the microgrids itself is necessary.
  - Coastal wind farms are susceptible to hurricanes, so distributed wind resources would allow communities to continue generating power.
  - Combine distributed solar with wind to overcome limitations of no sun or no wind. Combined with energy storage, this will increase the stability of the system.
- Sources:
  - https://en.wikipedia.org/wiki/San_Juan,_Puerto_Rico
  - https://www.aweablog.org/hurricane-update-small-scale-wind-aid-puerto-rico/

- https://www.nist.gov/sites/default/files/documents/2018/02/20/03_update_on_preliminary_reconnaissance_of_hurricane_maria_puerto_rico.pdf

Pending Issues

- Logan:
  - Costs associated with natural gas pipelines
- Ricardo:
  - Feasibility of DC Microgrid
  - Costs associated with battery storage
    - Compare storage implementation around the world to Puerto Rico
    - Clarify use of farms vs. distributed small storage and why
      - Breakdown of choices
  - Housing Act - Brainstorm how to get around
    - Solar water heating currently required.
- Heiqal:
  - Need to determine specific plan for locating microgrids.
    - Amount, centers, assets to protect
  - Housing Act - Brainstorm how to get around
    - Solar water heating currently required.
  - Test Plan
- Pinjia:
  - Need to compare renewable energy with worldwide market
  - Need costs of types of renewable energy
  - Need breakdown of potentials for renewable energy in Puerto Rico
  - Test Plan

Individual Contributions

Team Member	Contribution	Weekly Hours	Total Hours
Logan Lillis	• Write Weekly Report • Presentation on Natural Gas Pipelines • Presentation on Right of Ways • Creation and Formatting of final written proposal • Writing introduction, generation, transmission, some renewable energy, and some economics and policy sections of final written proposal • Gathering group information for IRP poster	15	49.5
Ricardo Rodriguez-Menas	• Research Tesla Powerwall and Powerpack pricing and rates • Research on BYD pricing and rates • Research on DC microgrids	8	49.5
Heiqal Zamri	• Research on Energy Storage ○ Costs, quantities, etc. • Research on microgrids compared to population density • Research on microgrid distribution	5	29
Pinjia Zhang	• Research on Wind Energy in Puerto Rico ○ Comparing renewable energy-capable areas to population density • Research on large-scale and distributed wind feasibility	6	27.25

Plan for Upcoming Week

All:

- Author relevant section(s) of white paper
- Send Logan information for IRP poster

Logan:

- Find more cost estimates for LNG port and pipeline
- Create IRP poster draft
- Continue writing sections of proposal

Ricardo:

- Further research on DC microgrids
- Analysis of Tesla vs BYD
- Write relevant sections of proposal.

Heiqal:

- Write relevant sections of proposal

Pinjia:

- Write relevant sections of proposal
- Update solar landfill statistics
- Update forest coverage distribution